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Chrysoperla carnea (Neuroptera :Chrysopidae) and biocides: Efficacious tools in controlling certain sugar beet insects

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Abstract

During two successive sugar beet growing seasons; 2021/2022 and 2022 / 2023. This field study was carried out at the Experimental Farm of Sakha Agricultural Research Station for recording the various prey of *Chrysoperla carnea* (Stephens) (Neuroptera :Chrysopidae) larvae predator by visual examination method, this predator feed upon their prey in the field. Moreover, investigated the toxicity of conventional, Clozemail, and biocides Xentari® insecticides on *Spodoptera* spp.(Noctuidae :Lepidoptera) and *C. carnea* larvae. The obtained results proved that the total numbers of prey were 197 and 196 individuals in two seasons, respectively. The most common prey was *Spodoptera* spp. (Eggs + larvae), leafhoppers, aphids, *Pegomyia mixta* Vill. (Diptera: Anthomyiidae) larvae, and *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) throughout the two seasons. In addition, the general meaning of reductions to *Spodoptera* spp. Larvae population due to Clozemail® and Pleo® was (82.17 and 84.11%) and (83.33 and 89.9%) during the two seasons, respectively. While Xentari® caused (77.36 and 77.65%) in two seasons, respectively. On the other hand, the general mean reduction in *C. carnea* larvae numbers was (83.33 and 89.90%) for Clozemail®, and (92.32 and 89.95/) for Pleo® in two seasons, respectively. Regarding the biocide, Xentari® induced reductions to the same predators with (26.85 and 22.85%) in two seasons, respectively. In conclusion, the combination and integration between *C. carnea* predator and biocides application are very good tools in IPM of sugar beet insects.

Introduction

Sugar beet is infested with numerous insect pests throughout the whole season, which leads to root and sugar yield reduction (Youssef *et al*., 2020 and Mansour *et al*., 2023). Among the insect pests, *Myzus persicae* (Sulzer) (Hemiptera: Aphididae), *Spodoptera exigua* (Hübner) (Lepidoptera: Noctuidae), beet moth (*Scrobipalpa ocellatella* (Boyd) (*Lepidoptera*: Gelechiidae), *Pegomyia mixta* Vill. (Diptera: Anthomyiidae), *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) and leafhoppers (Hemiptera: Cicadellidae) are commonly abundant and are destructive in sugar beet fields of Egypt, resulting in serious economic loss (Zheng *et al*., 2011 and Talaee *et al*., 2016).

These insects cause considerable economic losses and reduce the commercial value of the beet crop (Ahmadi *et al*., 2017), for example, the tortoise beetle, *Cassidae vittata* Vill. (Coleoptera: Chrysomelidae) is considered the most important insect pest in the sugar beet crop (Abou-Elkassem, 2010 and El-Rawy and Shalaby, 2011). Several studies have investigated the potential of *Chrysoperla carnea* (Stephens) (Neuroptera :Chrysopidae) larvae as a biocontrol agent against numerous insect pests such as *B. tabaci* (Kareim,1998), *M. persicae* (Carrillo and Elanov, 2004), Cicadellidae (Daane *et al*.,1996), mealybug (Hemiptera: Pseudococcidae) and mites (Acari) (Zaki and Gesraha, 2001), also, Farhan *et al*. (2019) reported the biological role in controlling insect pests in last two decades. The biological agents (Predators) belong to insect orders like Neuroptera which is used exclusively for pest management and feed on larval as well as adult stage.

The rearing of *C. carnea* has proven an effective strategy for the management of many pests such as whiteflies, aphids, thrips, coccids, mites, mealybugs, lepidopteran eggs, and a variety of other slow or non -moving soft -bodies arthropods. In such concern, Kandil *et al*. (2018) indicated that *C. carnea* is an important natural enemy. This predator has been observed associated with a wide prey range including aphid nymphs, eggs, and neonate larvae, of lepidopteran insects such as *Spodoptera littoralis* (Boisduval) (Lepidoptera: Noctuidae), *S. exigua* , scale insects, whiteflies, mites, and other soft bodies.

` Moreover, Mal *et al*. (2022) clarified that among the generalist predators available for managing various insect pests, *C. carnea* is a very important one and can be effectively exploited for controlling different insect pests in IPM programs. It has a wide host range of whiteflies, thrips, mealybugs, aphids, neonate lepidopterous larvae, and eggs of different arthropods in another study. Saleh *et al.* (2017) indicated that insect predators are the major group of biological control agents used for aphid control. Chrysopidae feed during the larval stages on different Sap-sucking pests including aphids, whiteflies, jassids, and mites as well as other small insects the neuropteran predators *C. carnea* and *Coccinella septempunctata* L. (Coleoptera: Coccinellidae) have attracted considerable attention as biological agents to control important agricultural pests in sugar beet fields.

In addition to, Hussain *et al*. (2012) demonstrated that *C. carnea* is an important natural enemy belonging to family Chrysopidae, order Neuroptera. The natural enemies are living organisms that kill or weaken the pests and cause their premature death or reduce their reproductive potential. It feeds on its prey or host and thus promotes its population. Natural enemies not only prevent the insects from attaining pest status but also reduce the damage potential of pests. Johanna *et al*. (2005) showed that *C. carnea* larvae are active predators and feed on aphids and other small insects. It has been used in the biological control of insect pests on crops. They feed not only on aphids but also on many other types of insects and even prey on larger creatures, such as caterpillars.

They can consume large numbers of prey and destroy aphid colonies. Biological control agents like predators are usually more sensitive to conventional insecticides than the target pests. The adverse impact of insecticides on predators can be decreased/controlled through the timing of insecticide application, choice of insecticide, and dosage. Selective insecticides can minimize the likelihood of the development of resistance in pests (Hussain *et al*., 2012). Also, Kandil *et al*. (2018) reported that the excessive use of insecticides, particularly those with long residual effects, has caused several harms to the natural balance between insects and their predators. On the other hand, Mansour *et al*. (2023) showed that Bacillus is a well-known bio-insecticide widely used to control insect pests with a high level of specificity against different lepidopteran species. The advantage of such bio-insecticides is safety to non-targeted beneficial organisms, enhancing conservation biological control of insect pests by reducing a negative impact on beneficial insects (Predators) in agricultural ecosystems.

The current study aimed to examine the various prey consumed by the larvae of *C. carnea* in agricultural fields. Furthermore, it aimed to evaluate the efficacy of conventional insecticides in controlling leaf cotton worms and the impact on *C. carnea* predators, as compared to bacillus insecticides.

Material and methods

1. Recording the different prey of *Chrysoperla carnea* larvae in the field:

These insecticides, as carried out at Sakha Agricultural Research Station during 2021/2022 and 2022/2023. The experimental area was measured with about half feddan planted with (Tarbelli variety) on the 1st and 2nd of August during the two seasons: respectively. All recommended practices were followed without insecticide application. Numbers of prey species were inspected by visual examination in the field/30 plants (During the larvae of *C. carnea* every sample ate a different prey). The samples were taken from 20th August to 20th December 2021/2022. Also, from 19th August to 19th December 2022/2023. The samples were recorded every 10 days intervals.

2. Impact of certain insecticides on *Spodoptera* spp. and *Chrysoperla carnea* field population:

In other fields, this trial was done during the two successive seasons:2021/2022 and 2022/2023 at the experimental farm of Sakha Agricultural Research Station. Tarbelli cultivar was planted on the 1st and 2nd of August during two seasons: respectively. Three insecticides (Table 1) were sprayed, one of them was biocides (Bacillus) and the others were traditional insecticides. Each insecticide was replicated four times (3 x 4 =12 replicates). Also, four replicates as checked. Each replicate measured 42 m^2. A completely randomized block design was assigned (CRBD). A knap sac sprayer (20. L volume) was used for spraying these insecticides. The date of spraying is on the 20th and 22nd of August during the two seasons, respectively. Inspection of 10 plants/replications was done just before the spraying and after 3,7 and 10 days post spraying. The larvae of *Spodoptera* spp. and *C. carnea* number were counted by visual record in the field.

3. Statistical analysis:

The reduction of Clozemail in insect number was calculated with Henderson and Tilton (1955) formula.

$$\text{Reduction \%} = \left\{1 - \frac{Ta\ x\ Cb}{Tbx\ Ca}\right\} \times 100.$$

Where: Ta=Numbers in treated plots after spraying, Tb=Numbers in treated plots before spraying, Ca=Numbers in check after spraying, Cb=Numbers in check before spraying. Differences between means were done using analysis of variance (ANOVA)at P=.05 using Minitab V.16 software (Duncan, 1955).

Table (1): Some insecticides sprayed against *Spodoptera* spp. during the 2021/2022 and 2022/2023 seasons.

Common name	Tradename	Category	Rate/feddan
Methomyl	Clozemail ® 90 % sp.	Conventional	300gm
Pyridalyl	Pleo ® 50% Ec	Conventional	100 cm^3
Biocide (Bacillus)	Xentari ® 54%WC *Bacillus thuringiensia* subsp. aizawai strain ABTS 1857	Alternative	200gm

Results and discussion

1. Recording the prey of *Chrysoperla carnea* larvae in the field during the two seasons:

In the 2021/2022 seasons, Data in Table (2) show that the total numbers of prey were 197 individuals throughout the season, divided into *Spodoptera* spp. eggs (16 with 8.12%). *Spodoptera* spp. larvae (62 with 31.47%), leafhoppers (7 with 3.55%). aphids (71 with 36.04), *P. mixta* larvae (Before entering the blotches) (26 with 13.19%), and *B. tabaci* (15 with 7.611%). Moreover, the number of prey ranges between 12 to 29 individuals during the seasons. Regarding the 2022/2023 seasons, findings in Table (3) indicated that the total populations of prey were 196 individuals during the seasons, consisting of *Spodoptera* spp. eggs (14 with 7.14%), *Spodoptera* spp. larvae (57 with 29.08%), leafhoppers (9 with 4.59 %), aphids (82 with 41.83%), *P. mixta* larvae (22 with 11.22%), and *B. tabaci* (12 with 6.12 %). In addition, the numbers of these prey range between 12 to 23 individuals throughout the whole season.

Table (2): The dominant prey species of *Chrysoperla carnea* larvae,30 plants/every sample by visual inspection method in the field,2021/2022 season.

Date	*Spodoptera* spp.				Leafhoppers		Aphids		*Pegomyia mixta* larvae		*Bemisia tabaci*		Total
	Eggs		Larvae										
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	
20/8	4	25.0	6	9.67	1	14.28	3	4.22	-	-	0	0.0	14
30/8	4	25.0	5	8.06	0	0.0	4	5.63	-	-	0	0.0	13
10/9	0	0.0	7	11.29	0	0.0	5	7.04	-	-	0	0.0	12
20/9	0	0.0	6	9.67	0	0.0	6	8.45	-	-	0	0.0	12
30/9	3	18.75	5	8.06	0	0.0	5	7.04	-	-	2	13.33	15
10/10	0	0.0	5	8.06	1	14.28	6	8.45	-	-	2	13.33	14
20/10	0	0.0	4	6.45	0	0.0	7	9.85	-	-	1	6.66	12
30/10	0	0.0	4	6.45	1	14.28	5	7.04	2	7.69	1	6.66	13
10/11	0	0.0	5	8.06	0	0.0	9	12.67	5	19.23	1	6.66	20
20/11	5	0.0	6	9.67	0	0.0	10	14.08	5	19.23	3	20.00	29
30/11	0	0.0	3	4.83	0	0.0	4	5.63	6	23.07	2	13.33	15
10/12	0	0.0	3	4.83	2	28.57	4	5.63	4	15.38	2	13.33	15
20/12	0	0.0	3	4.83	2	28.57	3	4.22	4	15.38	1	6.66	13
Total	16	-	62	-	7	-	71	-	26	-	15	-	197
%	8.12		31.47		3.55		36.04		13.19		7.61		

Table (3): The dominant prey species of *Chrysoperla carnea* larvae,30 plants/every sample by visual examination method in the field, 2022/2023 season.

Date	*Spodoptera* spp.				Leafhoppers		Aphids		*Pegomyia mixta* larvae		*Bemisia tabaci*		Total
	Eggs		Larvae										
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	
19/8	3	21.42	7	12.28	0	0.0	5	6.09	-	-	0	0.0	15
29/8	3	21.42	6	10.52	0	0.0	4	4.87	-	-	0	0.0	13
9/9	2	14.28	6	10.52	0	0.0	6	7.31	-	-	0	0.0	14
19/9	1	7.14	8	14.03	0	0.0	7	8.53	-	-	0	0.0	16
29/9	0	0.0	9	15.78	0	0.0	6	7.31	-	-	0	0.0	15
9/10	0	0.0	4	7.01	0	0.0	7	8.53	-	-	1	8.33	12
19/10	3	21.42	3	5.26	1	11.11	9	10.97	-	-	2	16.66	18
29/10	0	0.0	3	5.26	1	11.11	6	7.31	-	-	3	25.0	13
9/11	2	14.28	5	8.77	1	11.11	10	12.19	3	13.63	2	16.66	23
19/11	0	0.0	2	3.50	1	11.11	11	13.41	4	18.18	1	8.33	19
29/11	0	0.0	2	3.50	1	11.11	5	6.09	4	18.18	1	8.33	13
9/12	0	0.0	1	1.75	1	11.11	5	6.09	5	22.72	1	8.33	13
19/12	0	0.0	1	1.75	3	33.33	1	1.21	6	27.27	1	8.33	12
Total	14	-	57	-	9	-	82	-	22	-	12	-	196
%	7.14		29.08		4.59		41.83		11.22		6.12		-

These results agree with numerous investigators e.g. Kareim (1998), Zaki and Gershaha (2001), Maletal (2022), and Mansour *et al*. (2023). They proved that *B. tabaci*, leafhoppers, aphids, thrips, mealybug, Lepidoptera (Eggs + larvae), and mites are the dominant prey to *C. carnea* larvae in fields. In such concern, Hussain *et al*. (2012) indicated that *C. carnea* has received much attention from farmers and researchers as a biological pest control agent due to its polyphagous and voracious nature, vast geographical and distribution, and tolerance to certain insecticides. *C carnea* reported to give 100 percent lepidopteran pest control in fields.

2. Efficacy of some insecticides against *Spodoptera* spp. larva and its associated predator *Chrysoperla carnea* larvae during the 2021/2022 and 2022/2023 seasons:

In the 2021 /2022 seasons, Tables (4 and 5) show that the general mean of reductions to *Spodoptera* spp. Larvae due to Clozemail, Pleo, and Xentari insecticides were 82.17,83.33. and 77.36 %, respectively. The general meaning of reduction to *C. carnea* larvae was 83.33,92.32, and 26.85%, respectively. In 2022/2023, seasons, Tables (6 and 7) indicated the general means of reduction, after 10 days post spraying to *Spodoptera* spp. larvae due to the previous insecticides were 84.11,82.46 and 77.65%, respectively. On the other hand, the general meaning of reduction for *C. carnea* larvae was 89.90,89.95 and 22.85%, respectively. In conclusion, the biocide (Xentari) caused very acceptable reductions in *Spodoptera* larvae and, at the same time, concerned the populations of *C. carnea* larvae in comparison with conventional insecticides.

Table (4): General mean of reductions in *Spodoptera* spp. numbers due to applied certain insecticides, 2021/2022.

Treatment	Before Spray	After spray						Genera Mean of Reductions
		3		7		10		
	Mean.	Mean	Reduction %.	Mean	Reduction %.	Mean	Reduction %.	
Clozemail	15.75	5.75	66.71	2.75	86.29	1.50	93.51	82. 17 [a]
Pleo	14.75	5.0	69.09	2.50	86.69	1.25	94.22	83. 33 [a]
Xentari	15.25	7.25	56.65	3.25	83.27	1.75	92.18	77. 36 [b]
Check	15.5	17.0	-	19.75	-	22.75	-	-

Table (5): General mean of reductions in *Chrysoperla carnea* populations because of sprayed some insecticide, 2021/2022.

Treatment	Before Spray	After spray						Genera Mean of Reductions
		3		7		10		
	Mean	Mean	Reduction %.	Mean	Reduction %.	Mean	Reduction %.	
Clozemail	4.75	0.75	85.64	1.0	83.15	1.25	81.20	83. 33 [a]
Pleo	5.25	0.75	85.64	0. 5	92.38	0.5	96.59	92. 32 [b]
Xentari	5. 5	4.75	21.48	5.0	27.24	5.25	31.81	26. 85 [c]
Check	5.0	5.5	-	6.25	-	7.0	-	-

Table (6): General mean of reductions in *Spodoptera* spp. because applied certain insecticides in 2022/2023.

Treatment	Before Spray	After spray			General Mean of Reductions
		3	7	10	
	M.	M. ped.	M. ped.	M. ped.	
Clozemail	15.00	5.00 69.69	2.25 87.14	1. 0 95.50	84. 11 [a]
Pleo	14.75	5.25 67.64	2.50 85.47	1.25 94.28	82. 46 [a]
Xentari	14. 50	6.75 57.68	3.0 82.26	1.50 93.02	77. 65 [b]
Check	15.00	16.5	17. 5	22.25	-

Table (7): General mean of reductions in *Chrysoperla carnea* numbers due to sprayed certain insecticides, 2022/2023.

Treatment	Before Spray	After spray			Genera Mean of Reductions
		3	7	10	
	M.	M. ped.	M. ped.	M. ped.	
Clozemail	6.25	0. 5 92.36	0.75 88.54	1.0 88.80	89. 90 [a]
Pleo	6.0	0. 5 92.04	0.7 5 98.5	1.0 88.33	89. 95 [a]
Xentari	5. 75	5.25 12.84	5. 5 19.65	5.25 36.08	22. 85 [b]
Check	5.25	5.5 -	6.25 -	7.5 -	-

Many authors demonstrated that *C . carnea* predators are more sensitive to insecticides e.g. Hussain *et al.* (2012), Kandil *et al*. (2018), and Mansour *et al*. (2023). In another study, Ueno and Tran (2015) clarified that the excessive use of insecticides has a pernicious impact on predators and may result in environmental hazardousness.

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